ent. We do not know all that it is best to do yet, and still we do know that failure to close all the wounds means death to the patient, and some risk must be taken to avoid so great a hazard.

It needs no argument or demonstration to prove the harm resulting from tight suturing. It has been my experience to see in animals the edges of several wounds slough away to the extent of the bowel tissue included in the sutures, followed by extravasation, making a failure out of a case that otherwise gave good promise of being a success. The temptation is great to be over-sure of good union. In my experience peritoneal surfaces need only be laid in contact with each other and kept quiet for a few hours in order that adhesion may occur. The paralyzed condition of the bowel at the seat of wound from the injury, in itself favors this desirable quiet.

THE OSTEOGENIC FACTORS IN THE DEVELOPMENT AND REPAIR OF BONE.

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Proposition F.—The periosteum does not initiate the reproduction of bone, as the following facts show:

If a healthy adult bone be removed subperiosteally, without previous irritation, very little fresh bone is reproduced. The osseous matter which does appear is generally confined to a few nodules or plates scattered over the surface of the periosteum. The periosteal tube collapses, and its position is afterwards marked by a layer of fibrous connective tissue which ultimately becomes absorbed. The few osseous plates which do form are also apt to become absorbed, possibly from muscular movement which has been permitted to take place after the lapse of a time sufficient to allow of ossification. On stripping the periosteum from unirritated healthy bone, a number of vessels from the Haversian canals with their surrounding connective tissue, adhere to the periosteum and are detached along with it. The connective tissue surrounding the vessels in the Haversian canals is apt to have formative osseous cells entangled in it, they having probably been poured out consequent upon some interstitial change going on in the bone. It is probable that it is from such centres that the osseous nodules and plates, found on the internal surface of the periosteum, spring.

If a matured bone has been submitted to irritation for a sufficient time to enable new bone to be formed, and the old bone be then removed subperiosteally, good sound bone is reproduced. This is on account of the formative osseous elements having been poured out on the surface of the bone from the Haversian canals during the irritation of the bone, and becoming entangled in the meshes of the periosteum. A layer of new bone is thus formed on the periphery of the old, and on the under surface of the periosteum, which serves as a starting point for the formation of new bone by the proliferation of the osseous elements.

The result of extensive observation and experiment on these points may be thus summarized:

When acute suppurative periostitis is set up so as to denude the adult bone completely of its periosteal covering, and when the bone is at once removed, through a longitudinal incision, leaving the periosteum complete, and still maintaining its intimate relations with the surrounding soft parts, the subsequent course does not reveal any or almost any development of bone. As a rule, the walls of the periosteal tube tend to fall together, to coalesce and to form a fibrous layer which shrinks, through time, so that instead of a bone, half an inch in diameter, being formed, a mere connective tissue cord results. Or it may happen that a few spicules of bone may develop in the fibrous cord. Both of these are, bye and bye, absorbed.

If, instead of permitting the periosteal tube to fall together after the removal of the bone, it be stuffed in such a manner as to keep the walls separate, until filled with granulation, the result is not much different; the fibrous cord which remains may be thicker, but the development of bone is very meagre or absent. Even when irritation is maintained after the bone has been stuffed, no greater osseous development ensues.

It may be, however, asserted that in such cases the periosteum has participated in the inflammation to such an extent that its inner layers have been destroyed, and hence the osteogenic portions have been obliterated, bone production could not be expected. To meet this, data from two points could be furnished. First, it is just from such cases that well formed bone is produced under the periosteum. When the bone, instead of being removed, is allowed to remain in its place for a period of weeks or months, a thick layer forms a shell round the old bone. The osteoblasts have been thrown out in abundance from the bone, owing to its irritation, and have been accumulated in the meshes of the connective tissue. The second point is that when perfectly healthy periosteum is torn from a mature bone the connective tissue from the Haversian canals is partially removed with it, and it adheres to the periosteum. It is presumable that the nodules of bone which grow on the under surface of the periosteum are formed from the proliferation of the cells contained in the connective tissue removed from the Haversian canals. When the same periosteum is transplanted only small nodules of osseous matter form on the graft.

The bone is destitute of periosteum at those points where tendons are inserted into it. After removal of dead bone, the osseous matter develops quite as freely at those parts, as at the others covered with periosteum. It has already been seen that where the periosteum has been removed from the surface of a bone, cells have been poured from it, so as to cover this portion of bone, a new osseous layer being formed, as well as a superficial layer of connective tissue representing the periosteum.

OBS. XV.—Subperiosteal excision of the elbow has been performed by me on at least sixty cases. In it the periosteum is elevated from the olecranon, and distal extremity of the humerus, with the object of retaining *intact* the aponeurotic and muscular connections which are adherent to its outer surface. There are generally a series of osseous plates adhering to the under surface of the periosteum which have been abrupted from the softened bone on elevating the periosteum. If these osseous plates are allowed to remain, the cells composing them will proliferate, the plates will increase in size, fresh bone growing from them, often to such an extent as to render the movements of the elbow-joint muscle restricted. If, however, the periosteum be closely scrutinized, and all the osseous plaques be carefully removed from its surface, no fresh bone forms, union taking place by fibrous tissue. This occurs with a regularity and constancy that may be relied on, so much so that this practice of removing the osseous plates has been regularly carried out by me in these cases, with the invariable result of no fresh bone being produced from the periosteum which had been left intact.

In these cases, besides the grosser lesions of caries and necrosis, the olecranon has undergone interstitial changes often of an extensive kind, and in many instances it is softened. Occasionally, there are zones of new bone in the interior, and in immediate proximity of such are areas which are undergoing absorption. The chronic inflammatory action proceeding in the interior has caused a pouring out of cells from the Haversian canals, on to the surface of the bone where they have become ossified into plates, while these form part of the periphery of the bone. These, however, are easily separated from the softened bone, where the dense fibrous membrane is peeled from its surface.

Some suppose that in the case of fractures the soft tissues, muscles, etc., which surround the fracture contribute to the formation of ossifying callus. It is true that all the mesoblastic series of tissues are potentially convertible into one another; but there is no evidence for the belief that a healthy muscle, though injured, does assist in the regeneration of bone. The very same phenomena appears when bone has been accidentally obtruded into the interior of the cerebral tissue, and permitted to remain there, fresh osseous increments being added to it. This is well illustrated by several cases which have been seen by me, in which portions of fractured skull have been driven into the brain, and have been removed many months, and some even years subsequently. One may be summarized here.

Obs. XVI.—A patient had received a severe injury to the skull, by the fall of coal in a pit. Eleven months after he came under observation for symptoms demanding surgical interference with the skull and brain. Among other injuries, a portion of the internal table of the skull was found to have been detached and driven through the brain membranes into the brain where it lay for fully an inch in length, by three-quarters in breadth, completely surrounded by cerebral tissue. There was no distinct encapsulation of the bone. When removed, it was seen to have both sides equally polished, the roughened surface torn from the diploe, had been filled up with fresh deposition of bone, as were likewise the irregularities of its margins, which had been all rounded off. Therefore, this bone had grown after it had been detached from the interior of the skull, and while it was in contact with the cerebral tissue. It is presumed that no one will hold, that those fresh osseous deposits came from the cerebral tissue, they therefore must have come from the interior of the bone itself.

Were the soft tissues capable of contributing to the formation of ossific deposition when a fracture is produced, their intrusion between the fractured surfaces would be a gain. This, however, is just the reverse. When muscular or aponeurotic tissue intervenes between two fractured surfaces, it retards or absolutely prevents osseous union. One can only look for osseous union in such a case if the intervening membrane or muscular tissue dies or becomes absorbed. If it retains its vitality, it will prevent osseous deposition. If the portion of intervening tissue be small, relatively, to the fractured surface, then the ossific deposition from the fractured surface may be poured out to a sufficient extent to effect osseous union, the intervening soft tissues becoming slowly absorbed, leaving, however, in the bone a crevice or other irregularity to indicate its former seat. Nor is the periosteum any exception to this rule. When it has been permitted to be peeled up and stretched across one fractured surface, intervening thus in the osseous breech, union takes place by fibrous tissue. The ossific deposition being then absolutely limited by the membrane.

On two occasions this has been found by me to have been the sole cause of non-osseous union. In one very recent case an ununited fracture of the femur was found to have resulted from the periosteum of the proximal fragment having become stretched over the fractured extremity. Numerous opportunities have been given to demonstrate the fact in compound fractures that the periosteum may be tore from one fragment and laid over one or other fractured surfaces.

This has been more frequently seen in comminuted fractures, and were it not for the fact that the periosteum is normally so tightly stretched over the bone, it would be made frequently the cause of non-osseous union.

The amount of the provisional callus depends upon not only the displacement of the fragments, the movements they have been subjected to, but also to the extent of the separation of the periosteum. The periosteum acts as a limiting membrane to ossific deposits from the interior of the bone. This is well illustrated in fractures. When a simple fracture has been produced without rupture of the periosteum, the union of bone occurs so perfectly that it is difficult after a time to discern the seat of fracture, and at no time is there much, if any, provisional callus. True, there is a slight deposition of bone under the periosteum for a short distance above and below the seat of lesion; but even this very soon wears down, and can only be detected at the beginning when the bone is superficial like the tibia. Even this thickening may not ensue if the parts be kept perfectly at rest, from the instant the fracture is produced, as is the case frequently in osteotomies, the bone having been cut across, and immediately placed in accurate apposition and maintained there until ossification has been perfected. The part where the periosteum has been cut by the osteotome generally shows a thickening of bone, though this depends upon the extent of hiatus which has been left in the rectification of the deformity.

If, on the other hand, the fracture has been attended by tearing of the periosteum, and the limb has been subjected to much movement subsequent to the production of the osseous lesion, then a large amount of ossific material will be poured out from between the fractured surfaces into the gap, and surrounding the exterior of the bone. The limiting membrane of the periosteum having been ruptured, and perhaps separated from the extremities of the fracture, the movements made will express the contents accumulated in the osseous gap, and there will form fresh deposits outside the bone. Again, in malposition of the fragments the ossific matter is often poured out in great abundance; but, if there be on any side a continuity of the periosteum it will limit the osseous deposit at that part. Frequently, in fractures the ossific material poured out from the bone lesion covers in the periosteum. In such a case the callus is only loosely attached to the bone, and may be easily peeled off, unless the periosteum becomes absorbed, when intimate organic adhesion takes place. The very form which the callus assumes, that of a spindle-shaped swelling round the fracture, its greatest diameter being opposite the gap in the bone, and tapering off toward the proximal and distal portions of the shaft, point to the ossific matter being poured from the breach in the bone instead of coming from the periosteum or the neighboring tissues. Besides, it must be remembered that the provisional callus is not to be found alone on the circumference of the bone, but also in its interior filling up the medulla. This osteoplastic effusion can scarcely be claimed as coming also from the periosteum; the latter would indeed be a prolific membrane, if, considering its thickness, it would supply not only the mass of provisional callus on its exterior, but also the callus in the interior of the shaft of the bone. This callus is thrown out from the fractured surfaces, and also is commensurate with the amount of irritation set up.

Callus thrown out from the fracture may in certain cases be superimposed on the periosteum.

OBS. XVII.—A man, æt. 25 years, met with a severe machinery accident, whereby he was so severely injured in various parts of the body that he died at the end of five weeks. One of these was a compound fracture of the lower third of the thigh produced by a blow from a revolving knife which penetrated the tissues to the bone and cut the inner third of the femur in two, the fracture being completed by impact against another part of the same machine. This wound healed by first intention. At the post-mortem examination the fractured femur was found to have been fairly well united, but the apposition of the fragments was not exact. The lower one projected about quarter of an inch beyond the upper, thus causing an abutting shoulder on the inner side, while a corresponding one from the upper fragment projected on the outer side. Over the latter the periosteum was continuous, from the upper to the lower fragment, and at that point it limted the osteoplastic growth from the bone. In the inner side, where the periosteum had been cut in two, it still retained its position on the upper and lower fragments, there being no bridging from the projecting shoulder below to the shaft above. That portion of the periosteum on the inner side of the upper fragment adhered to the bone as far as the cut surfaces. Underneath its very edge there was a slight fresh osseous deposition, while above it there was superimposed a mass of newly formed callus, which extended in one piece from the projecting fractured ledge of bone to half an inch up the shaft. It measured fully half an inch in thickness—just the extent of the projecting shoulder—and tapered from that to its termination, half an inch above. All this lay superimposed on the periosteum. A very thin new layer of connective tissue was already beginning to form on the outside of this mass.

Here, then, the callus was poured out from the cut surface of the bone, and actually buried half an inch of the periosteum covering the neighboring fragment.

Bones are subject to constant interstitial changes.

Bones are subject to constant interstitial changes, and are affected by a variety of causes, such as the state of health of the individual, the amount of exercise he subjects himself to, the quantity and quality of food he consumes, and the state of his secretory and excretory functions.

In the various periods of life the changes in the bones are well known. In the young they are much more soft and vascular, consisting more of cancellated tissue than cortical, and growing in length principally from the epiphyseal extremities. In adult life, the cortical layer is much greater, much denser, and the bone generally harder, although it is still possessed of elasticity. In old age the cortex is thinner, more earthy, and much more brittle, while the medullary cavity is enlarged and fatty. In debilitating diseases the bones are early affected, and often powerfully so, great absorption taking place, while in convalescence there is a regeneration and redeposition. These changes are not merely on the surface or in the medulla, but are interstitial, and in adult life proceed, while there is very little appearance of increased activity in the periosteum, with the exception that it participates in the vascularity occurring in the whole bone.

In children the rapidity with which these changes occur is so marked that within a few weeks from the occurrence of debilitating illness, the bones may become softened and easily bent. While after a few weeks of convalescence the bones again become firm, and in the course of a couple of months, under suitable treatment, are more solid and firmer than prior to the illness. In some such cases the debilitating influence produced a great absorption of the cortical layer, the calibre of the medullary cavity being augmented, and the cancellated tissue greatly rarefied, its place being taken by fat. When convalescence has been fully established, a considerable increase in the volume of the cortical substance ensues, so much so that frequently the whole medullary cavity of the bone is filled up, so that it becomes a solid rod. At a later period, this solid rod becomes honey-combed by resorption of the solid contents in the interior, and a medullary cavity is ultimately restored, the cancellated tissue passing back to its normal consistence. Now, all these phenomena occur in the interior of the bone by interstitial change, and few of them involve the periosteum.

Pressure on the interior of a bone causes interstitial absorption, as may be seen in the process of pegging fractures with steel pins. Though when inserted they are caught firmly on all sides, yet, in three weeks they have become so loose that they may be easily lifted out with the fingers.

When a long bone has been severed in its continuity, as in an amputation, the healing takes place by the lower extremity being covered over by a mass of new bone.

The ossific elements are projected first from the medullary cavity along with the mass of granulation tissue which is poured out there from the crevices which have been formed in the rarefied cortical layer, the cut periosteum not participating in the general development of the callus. The form of the granulation tissue which ultimately becomes osseous, is dome-shaped over the extremity of the bone, the greatest convexity being opposite the medullary cavity, and from this it tapers off toward the circumference of the bone, ending at the commencement of the periosteum. Here again the periosteum does participate little, if at all, in the osseous formation.

Proposition G.—Bone may be regenerated independently of the medulla, which may itself be reproduced.

In certain instances of osteomyelitis, where the whole of the medulla and the interior of a growing bone has been the seat of inflammation, producing a softened purulent pulp, enclosed in a shell of thin, though true bone, representing the cortical layer, the whole of the interior has been washed out, and after a prolonged period, complete restoration of the calibre of the bone has resulted, though in some instances, the growth in length has been interfered with, probably from involvement of the epiphyses. One such instance may be here summarized:

OBS. XVIII.—A lad, æt. 10 years, had complete destruction of the ankle-joint and bones of the foot, but besides had chronic osteomyelitis of the tibia. For the former, Syme's amputation had to be performed, but besides, the interior of the shaft of the tibia was filled with a dark chocolate pulp mixed with pus. This extended from the upper tibial epiphysis to the lower, the latter of which had been completely obliterated. The whole cavity of the tibia was filled with it, the cancellated tissue having disappeared. When the shaft was opened into, the inflamed purulent pulp flowed out. The cavity was then washed, when it was seen to be entirely empty, a shell of bone being left representing the cortex. This shell was composed for the most part of young bone. In the course of a few months the external layer of bone had increased in thickness. A new medulla had formed in the interior, and ossification had advanced in the centre of the bone, though it was distributed in irregular masses. At the termination of eight months the shaft was sufficiently firm to enable him to bear the weight of his body upon it while walking. Four years afterwards he was examined, when he stated that he walked about on it for long distances with ease. The limb was, however, considerably shorter, owing probably to the destruction of the distal epiphysis. He therefore required to wear an extra high heeled boot.

In these instances the inflammatory action had probably been initiated in the medulla, causing a pouring out of osteoblasts through the Haversian canals on to the periphery of the bone, where a new osseous layer was deposited between the bone and the periosteum.

After the inflamed medulla had been removed, a fresh deposit of bone filled up the cavity centripetally. This ultimately became hollowed out, and a fresh medulla was formed.

Such observations show that bone may grow and be reproduced without any medulla, and that the latter may be regenerated through the medium of the osseous tissue. Had the osseous plaques which were deposited from the bone, and which were adhering to the periosteum in these cases, been carefully taken away, then no reproduction of bone would have ensued; the tube would have collapsed, and except for the growth from the proximal epiphysis, the bone would have entirely disappeared. In many other cases the whole of the medulla has been found converted into a purulent mass, and has been washed out, and occasionally the whole interior scraped with a Volkman's spoon. The aperture has filled up with granulation tissue, and the parts have healed, the limbs being restored to perfect use.

Proposition H.—The histo-genetic phenomena support the foregoing observations, showing that the periosteum does not generate bone.

It is acknowledged that the growth of cartilage occurs from the cells, and the periplast or intercellular substance is secreted by the cells, around each of which a clear homogeneous capsule is found, at first appearing distinct, though becoming by and by fused into the surrounding matrix, and this process may be clearly traced. Yet, cartilage in the long fœtal bones is surrounded by a perichondrium, and no one attributes the growth of the cartilage to this outer layer of firm fibrous tissue, which ultimately becomes changed in *name* from perichondrium to periosteum. If intra-cartilaginous ossification be traced, it is seen that at an early period a rod of hyaline cartilage shaped like the future bone is formed, and this is surrounded by a perichondrium. The ossification begins at the middle of the shaft and extends toward the extremities. There is first a proliferation of the cartilage cells and an infiltration of the cartilage matrix with lime salts. This calcified matrix does not become the future bone, but disappears. The matrix is absorbed, blood vessels growing into it. Medullary spaces are formed which are filled with cells. The trabeculæ between these spaces become covered with a thin layer of osseous tissue which is produced by osteoblasts. These cells assume an elongated branched shape when they are about to become cells. The bone matrix is a periplast, produced by osteoblasts, each cell secreting a matrix which becomes calcified. As the layer of young bone thickens, the trabeculæ of cartilage disappear by absorption. Giant cells (osteoclasts) absorb portions of the intervening trabeculæ, and in this way produce a medullary canal in the centre of the shaft. A layer of cartilage persists at the epiphysis until growth in length has ceased.

All this is clear. It is only when intra-membranous ossification is dealt with that the growth of bone is attributed to the periosteum. Those who hold to this opinion base it upon the fact that in certain stages of bone development a layer of osteoblasts is seen under the periosteum, which develops into osseous tissue superimposed upon the cortex of the bone. In considering this point it is seen that this peripheral layer of osteoblasts, formed under the periosteum, is not only in immediate contact with the bone, but the osseous structure is actually in continuity with this layer of osteoblasts, the bone growing centrifugally by the superposition of osseous lamellæ with their enclosed bone corpuscles; and if the manner in which this takes place be observed, it is seen that the osteoblasts send shoots radiating outward into the periosteum, their base being in the bone. At an early stage of ossification, two processes are observed, a deposition of earthy matter in the matrix of the cartilage, and a deposition of true membrane bone closely investing the surface of the cartilage under the perichondrium. From this true membrane bone, the osteoblastic ossification extends centripetally, the calcified cartilage matrix being previously excavated by osteoclasts. If the opinion adopted by Muller—the one which has received most adherence—be accepted, the cartilage cells are converted after undergoing division, into osteoblasts. If this be admitted, it is evident that the cartilage cell being the parent of the osteoblast, it does away with the possibility of regarding the periosteum as the secreting or generating membrane. But the layer of osteoblasts is not only formed on the periphery of the shaft under the periosteum, but continues in unbroken line all through the Haversian spaces and canals, and even occasionally lines the medullary border. At any part where they are formed, bone is developed from them. Why the mere finding of layers of osteoblasts on the periphery of the bone should permit any one to conclude that the periosteum is transformed into, or that it secretes bone—for that is the substance of many statements on the subject—it is difficult to understand.

The osteoblastic layer found peripherally in fœtal and young bones during their development, belongs to the bone rather than to the periosteum for the following reasons. First, descriptions of parts should be taken from their fully matured state and not from what is seen during their evolutionary stages. Though this layer of osteoblasts is found on the periphery of the bone under the periosteum during osseous developmental stages, yet in fully matured, healthy bone, it is either wanting, or has assumed the most meagre proportions. Secondly, if these osteoblasts were only to be seen under the periosteum and no where else, it might be questioned whether they belonged to bone or periosteum, but as they are found even during the processes of osseous development, not only on the periphery of the bone, but also throughout the whole osseous tissue lining the Haversian spaces and canals, the conclusion is that they belong to the bone as a whole.

The initial origin of the osteoblast is not thereby prejudged. Even were Muller's view accepted that cartilage cells, after undergoing evolutionary processes, are converted into osteoblasts, it is still probable that the connective tissue corpuscles derived, as they are, from the same germinal layer, may be, under peculiar circumstances, developed into osteoblasts, as the whole of the differentiated tissues, derivable from this layer, are potentially convertible into one another.

In irritation of an adult bone, the first thing noticed is the congestion of the medulla, which is the more easily produced on account of the medullary vessels not being accompanied by a solid framework.

Synchronal with the congestion there is a rapid proliferation of cells in the bundles of connective tissue which accompany the Haversian canals. At an early stage these cells are found superficially, between the bone and the periosteum, congregating round the blood-vessels at the orifice of the Haversian canals. They appear as if pressed out from these canals, having traveled in the direction of least resistance, and so gained the free surface of the bone under the periosteum. Shortly after they are found more evenly distributed under the periosteum, when this special grouping round the Haversian orifices becomes observed. This egress of cells from the Haversian canals to the surface of bone under the periosteum, is analogous to the pouring out of cells, which takes place from the fractured extremities of bone. The walls of the Haversian canals meanwhile undergo absorption, probably from pressure, possibly from some special action produced by the osteoblasts. The notches and spaces formed by the erosions of the osseous lamellæ (Howship's lacunæ) are otherwise filled with cells.

All these cells found in the medullary spaces, the Haversian canals, and under the periosteum, are identical, and the cell formations in their various parts are identical, the one with the other. The cells are small, round or polygonal, and consist, for the most part, of embryonic osteoblasts. When in the process of absorption a breach is made in the wall of the bone capsules, the bone cells having become converted into their embryonic state, escape and mix with these cells already in the medullary spaces, and become undistinguishable from them.

Ossification of these cellular elements takes place in the cavities hollowed out in the bone, in the widened Haversian canals, and under the periosteum, all in the same way. The subperiosteal osteoblasts possess the power of reproduction in a high degree, but once the irritation has been removed from the walls of the absorption spaces made in the bone, and from the widened Haversian canals, the osteoblasts ossify quite as quickly and as completely as they do under the periosteum. Besides, it must not be forgotten that under suitable conditions, the new osseous tissue develops rapidly on the surface of the bone denuded of periosteum.

The histological evidence, therefore, shows that the osteogenic matter is concentrated in the osteoblasts—either in their embryonic state or in their fully formed condition—which are found first in the interior of the bone, in the connective tissue surrounding the vessels, in the Haversian canals, and traveling from these spaces on to the surface of the bone, whether covered by periosteum or not, and also under certain circumstances into the central cavity. In the young bone these cells are found on its surface under the periosteum, and in these circumstances the periosteum, if elevated, would, in all probability, carry along with it a sufficient supply in its meshes to reproduce some bone. In the adult there are few of these cells on the surface of the bone in a state of health, but if the bone be irritated, these cells are found shortly after, entangled in large numbers in the lower layer of the periosteum.

The osteoblasts likewise fill the hollows or cavities which may exist in the bone, or which may be formed there by coexisting pathological changes, and once the excessive irritation is removed, ossification takes place within these quite as perfectly as it does on the surface of the bone. These cells may be poured out and develop on the surface of an osseous fragment, on the under surface of bone, in the central medulla, over or under the periosteum, as in some simple fractures. They are found in abundance on the surface of young growing bones, while on the surface of matured healthy bones they are absent, or very few in number. They are found in the immediate tissue lining the Haversian canals in natural healthy bone, owing to the constant interstitial change which goes on till after middle life.

On irritation of bone these round cells accumulate in such numbers in the connective tissue lining the Haversian canals that compression of the vessels would quickly ensue and necrosis result from the cutting off of the blood supply, if two things, both probably the result of pressure, did not supervene. First, these cells are so pressed on that they travel in the direction of least resistance, and so congregate in large numbers on the surface of the bone; when the periosteum covers the bone it serves as a protecting limiting membrane, which supplies them with nutriment. Secondly, the calcareous wall undergo rapid absorption, their place being taken by these round cells, which on the subsidence of irritation, are rapidly converted into osseous tissue.

When a matured healthy bone is subjected to irritation, cells are poured out under the periosteum. As the irritation continues the periosteum becomes hyperæmic, much softer, and more swollen than usual, and the meshes of its under stratum become loaded with osteoblasts. Ossification may then proceed on the surface of the bone, where it is often deposited in irregular nodulated masses.

By way of conclusion, it may be stated that a study of the whole subject, from histogenesis to experimental inquiry and pathological observation, shows that bone is produced and regenerated by proliferation of osteoblasts, and its development and reproduction can take place independently of the medulla and periosteum. The periosteum acts as a sheath, as a protecting limiting membrane, through which the bone receives some of its blood supply, a very important portion being provided by the nutrient vessels. The cells of which the bone is composed are capable of living, separated from periosteum and medulla; they possess the power of proliferation, and consequently of regeneration of osseous tissue.

These conclusious, if accepted, indicate to the surgeon the value to be attached to the various elements, entering into the formation of bone. While not underestimating the periosteum, as a medium through which blood vessels reach the bone, and as a limiting and protecting membrane, of great use in many pathological conditions, he will no longer regard it as the structure which can secrete or reproduce bone. He will not trust the periosteum to regenerate bone unless it has adherent to it sound osseous plaques, the elements of which have the power of proliferation, and from these alone can osseous regeneration proceed. He will not discard injured osseous tissue under the belief that it must necessarily die, merely because it is divested of periosteum; but he will regard it as a tissue, possessed of great independent vitality, which, if placed in suitable media, where blood serum is plentiful, and where blood vessels can quickly be thrown out, is capable of living and growing. With that belief limbs, which otherwise would be sacrificed, may be saved.